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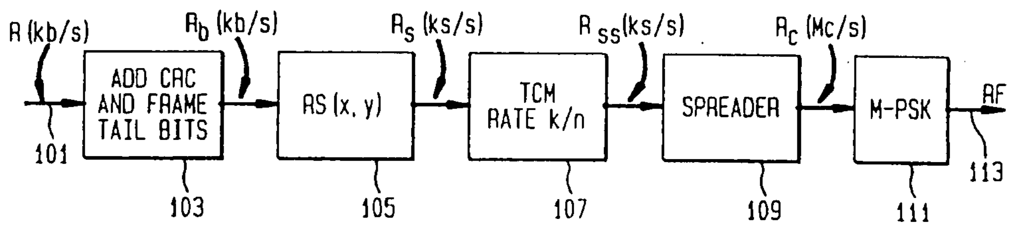
(51) Int.Cl.^{6} H04B 7/185, H04B 1/69, H04L 1/22
(30) 1997/04/03 (832,548) US

(54) **METHODE ET APPAREIL POUVANT EFFECTEUR DES TRANSMISSIONS SPECTRALES EFFICACES DE SIGNAUX MODULES AMDC**

(54) **METHOD AND APPARATUS FOR SPECTRAL EFFICIENT TRANSMISSION OF CDMA MODULATED SIGNALS**



(57) Dans un système de transmission multipoint-point, un signal de communication à codage de Reed-Solomon est soumis à une modulation à codage turbo ou à codage en treillis avant un étalement orthogonal effectué sur le spectre du signal de l'utilisateur et sur des faisceaux à signaux multiples. Le signal étalé résultant est transmis sous la forme de faisceaux RF.

(57) In a multi-point-to-point transmission system, a Reed Solomon encoded communication signal is Turbo or Trellis code modulated prior to an orthogonal spreading operation performed on the user signal spectrum and on multi signal beams. The resultant spread signal is transmitted as beams at RF.

Method And Apparatus For Spectral Efficient Transmission Of CDMA Modulated Signals

Abstract

In a multi-point-to-point transmission system, a Reed Solomon encoded communication signal is Turbo or Trellis code modulated prior to an orthogonal spreading operation performed on the user signal spectrum and on multi signal beams. The resultant spread signal is transmitted as beams at RF.

The invention claimed is:

1. In a wireless transmission system having a plurality of terrestrial transceiver stations and a satellite in the sky transceiver station, signal processing apparatus for a multi-point-to-point communication system coupling the ground transceiver stations to the satellite transceiver station and in which pluralities of individual user signals are bundled into a lesser plurality of beams containing multiple user signals for enhancing spectral efficiency, comprising:

each transceiver station including:

radio transmission circuitry having:

signal framing circuitry;

Reed-Solomon encoding circuitry connected for encoding framed signals;

convolutional concatenated modulating circuitry connected for modulating the Reed-Solomon encoded framed signals;

circuitry joining user signals into beams having a plurality of user signals. including spreading circuitry for spreading and overspreading the modulated signals with first and second spreading codes for signal and beam respectively with at least one of the first and second codes being orthogonal for achieving maximum separation between the beams and signals;

RF signal generation circuitry and associated radiation antennas connected for wireless transmission of the spread and over spread signals and beams into an air interface;

radio reception circuitry having:

demodulation circuitry for received RF signals

de spreading and de over spreading circuitry for received demodulated signals;

decoding and phase recovery circuitry for received de spread and de over spread signals;

Reed-Solomon and Convolutional concatenated decoder circuitry for recovering information signals.

2. The wireless transmission system of claim 1, comprising:

the convolutional concatenated coding circuitry comprises trellis code modulator circuitry joining user signals into beams having a plurality of user signals with a TCM rate of 3/4.

3. The wireless transmission system of claim 1, comprising:

the convolutional concatenated coding circuitry comprises a trellis code modulator circuitry joining user signals into beams having a plurality of user signals with a TCM rate of 2/3.

4. The wireless transmission system of claim 1, comprising:

the convolutional concatenated coding circuitry comprises a Turbo code modulator circuitry joining user signals into beams having a plurality of user signals with a Turbo rate of 2/3.

5. The wireless transmission system of claim 1, comprising:

the convolutional concatenated coding circuitry comprises a Turbo code modulator circuitry joining user signals into beams having a plurality of user signals with a Turbo rate of 1/2.

6. The wireless transmission system of claim 1, comprising:

the Reed-Solomon encoding circuitry connected for encoding framed signals having a coding rate of (32,16).

7. The wireless transmission system of claim 1, comprising:

the Reed-Solomon encoding circuitry connected for encoding framed signals having a coding rate of ($16\lambda, 15\lambda$).

8. In a wireless multi-point-to-point transmission system coupling two communication stations, in a wireless transmission medium the signal processing defined by steps of:

Trellis code modulating an encoded signal;

spreading and overspreading the Trellis code modulated user signals to generate a spread spectrum signal and combining selected user signals into beams which are spread and overspread;

transmitting the spread spectrum beam by wireless transmission techniques, whereby the individual user signals and beams are is substantially non-interfering with one another.

9. In a wireless multi-point-to-point transmission system coupling two communication stations, as claimed in claim 8, further including the steps of:

Reed Solomon encoding of the user signals;

using orthogonal codes for the spreading and overspreading process, with orthogonal spreading codes applied to beams to insulate beams from other beam code interference and with orthogonal spreading codes applied to user signals to identify individual users.

10. In a wireless point-to-point transmission system coupling two communication stations, as claimed in claim 8, further including the steps of:

Reed Solomon encoding of the user signal; and

using semi-orthogonal spreading codes applied to beams ;

11. In a wireless multi-point-to-point transmission system coupling two communication stations, as claimed in claim 8, further comprising the steps of:

transmitting signals as phase shift key signals.

12. A signal processing system for improving spectral efficiency of a transmission link by preventing intersignal and interbeam interference, comprising:

means for encoding a framed user signal;

means for Trellis code modulating the encoded user signal connected to the means for encoding;

means for Trellis code modulating and by spreading generating a spread spectrum signal;

means for over spreading the spread spectrum signal;

means for combining user signals into multi-user beam signals; and

means connected to the means for spreading output for phase shift keying the spread spectrum signal.

13. A signal processing system for improving spectral efficiency of a transmission link, as claimed in claim 12, further comprising:

the means for spreading including means to spread the Trellis modulated signal with an orthogonal user code and a beam PN code.

14. A signal processing system for improving spectral efficiency of a transmission link, as claimed in claim 13, further comprising:

the means for spreading further including means to spread the Trellis modulated signal combined into a beam with an orthogonal beam code.

15. A signal processing system for improving spectral efficiency of a transmission link, as claimed in claim 12, further comprising:

means for applying sine and cosine multipliers to the spread signal for phase shift keying the spread signal.

16. In a wireless transmission system coupling two communication stations, wireless transmission defined by a signal process method; comprising the steps of:

modulating an encoded signal by a convolutional parallel concatenated coding scheme followed by interleaving;

spreading and overspreading the modulated signal and combining signals into beams to generate a spread spectrum beam for wireless transmission.

17. In a wireless transmission system coupling two communication stations, as claimed in claim 16, further defined by the steps of:

encoding a signal by Reed-Solomon coding prior to modulating.

18. In a wireless transmission system coupling two communication stations, as claimed in claim 16, further defined by the steps of:

using orthogonal spreading codes for the spreading process.

19. In a wireless transmission system coupling two communication stations, as claimed in claim 16, further defined by the steps of:

using orthogonal spreading codes for maintaining isolation of beams from interbeam interference.

20. In a wireless transmission system coupling two communication stations, as claimed in claim 16, further defined by the steps of:

using orthogonal spreading codes for maintaining separation between user channels.

21. In a wireless transmission system coupling two communication stations, as claimed in claim 16, further defined by the steps of:

Reed Solomon encoding of the signal;
using semi-orthogonal spreading codes applied to beams.

22. In a wireless multi-point-to-point transmission system coupling two communication stations, defined by the signal process steps of:

Turbo code modulating an encoded signal;

spreading and overspreading the Turbo code modulated signal to generate a spread spectrum signal.

23. In a wireless multi-point-to-point transmission system coupling two communication stations, as claimed in claim 22, further defined by a beam signal sub-banded into user channels; further including the steps of:

Reed Solomon encoding of the signal;

using orthogonal codes for the spreading process, with orthogonal spreading codes applied to beams to insulate beams from other beam interference and with orthogonal spreading codes applied to user channels to identify individual users.

24. In a wireless multi-point-to-point transmission system coupling two communication stations, as claimed in claim 22, including the step of:

transmitting signals as phase shift key signals.

25. A signal processing system for improving spectral efficiency of a transmission link, comprising:

means for encoding a framed signal;

means for Turbo code modulating the encoded signal connected to the means for encoding;

means for spreading and overspreading the Turbo code modulated signal connected to the means for Turbo code modulating and by spreading and overspreading generating a spread spectrum signal; and

means connected to the means for spreading output for phase shift keying the spread spectrum signal.

26. A signal processing system for improving spectral efficiency of a transmission link, as claimed in claim 25, further comprising:

the means for spreading and overspreading including means for spreading and overspreading the Turbo modulated signal with an orthogonal user code and a beam PN code.

27. In a wireless multi-point-to-point transmission system, as claimed in claim 8, including a step of:
trellis code modulating at a TCM rate of 3/4.

28. In a wireless multi-point-to-point transmission system, as claimed in claim 8, including a step of:
trellis code modulating at a TCM rate of 2/3.

29. In a signal processing system, as claimed in claim 12, including:
means for trellis code modulating at a TCM rate of 3/4.

30. In a signal processing system, as claimed in claim 12, including:
means for trellis code modulating at a TCM rate of 2/3.

31. The method of claim 16, wherein:
modulating includes trellis code modulating at a TCM rate of 3/4.

32. The method of claim 16, wherein:
modulating includes trellis code modulating at a TCM rate of 2/3.

33. The method of claim 16, wherein:
modulating includes Turbo code modulating at a Turbo rate of 2/3.

34. The method of claim 16, wherein:
modulating includes Turbo code modulating at a Turbo rate of 1/2.

35. The signal processing system of claim 25, wherein:
the means for Turbo code modulating operates at a Turbo rate of 2/3.

36. The signal processing system of claim 25, wherein:

the means for Turbo code modulating operates at a Turbo rate of 1/2.

FIG. 1

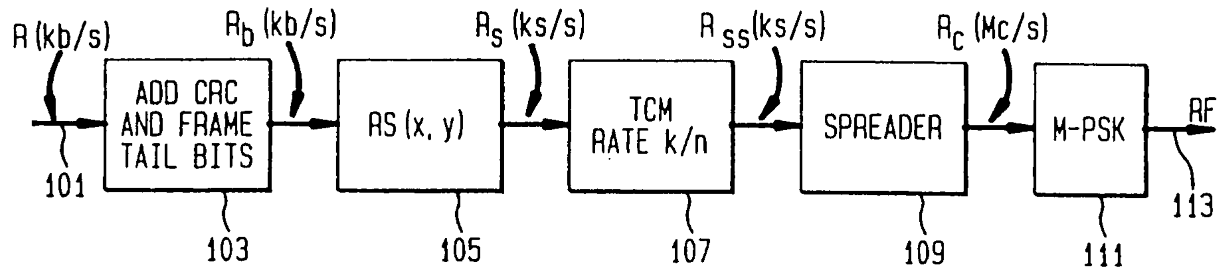


FIG. 2

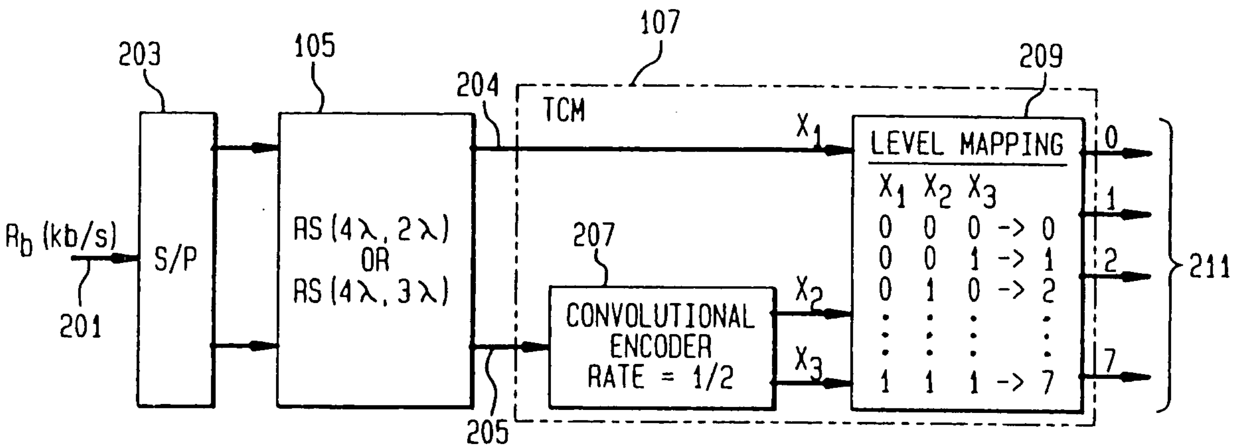


FIG. 3

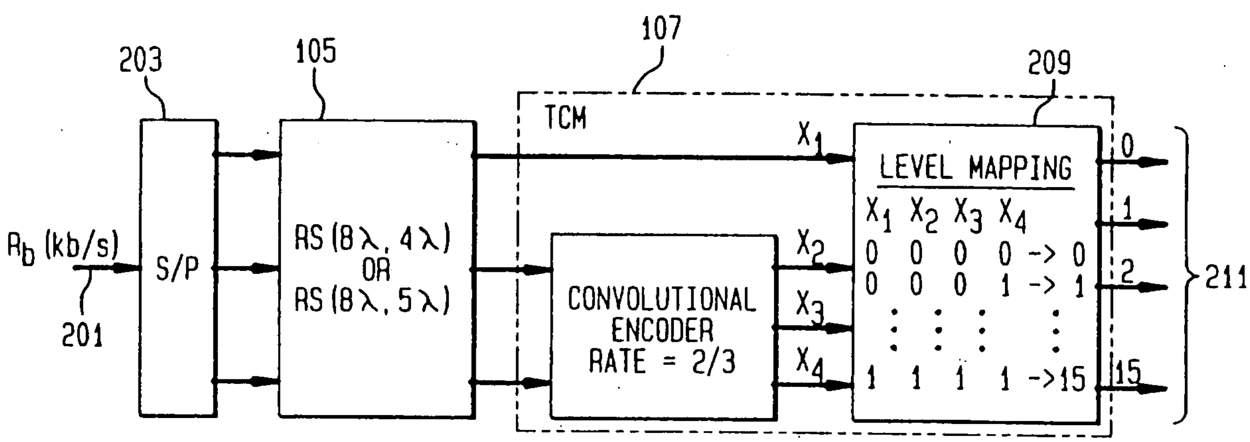


FIG. 4

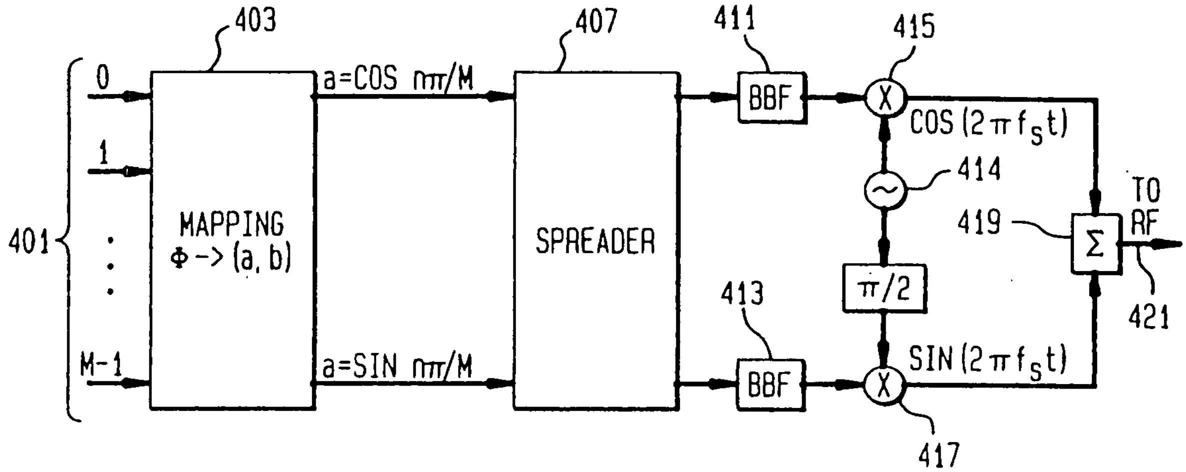


FIG. 5

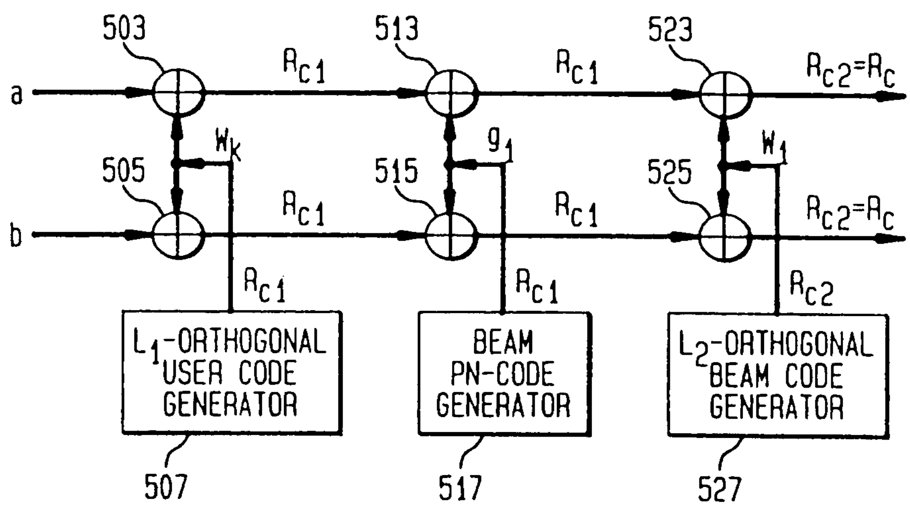


FIG. 6

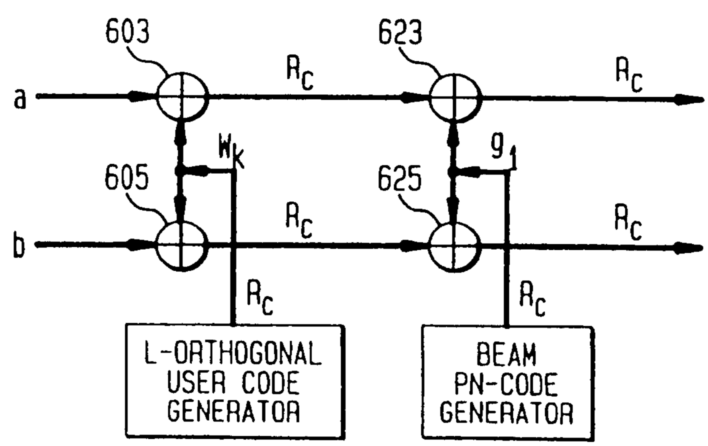
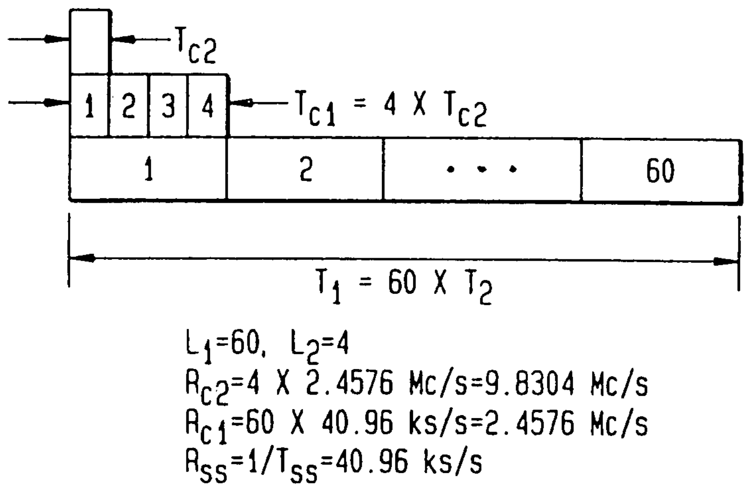
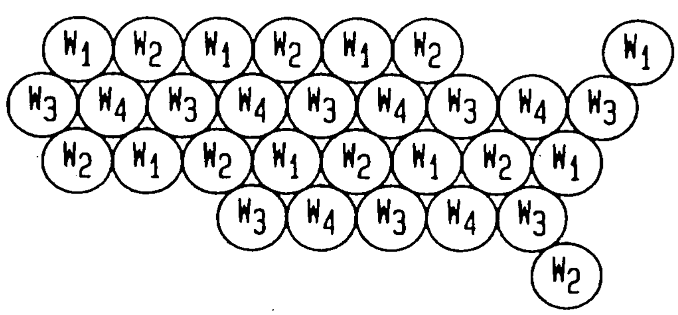


FIG. 7



T_{c2}
1 2 3 4
$T_{c1} = 4 \times T_{c2}$
1
2
...
60
$T_1 = 60 \times T_2$
$L_1=60,\ L_2=4$
$R_{c2}=4 \times 2.4576$ Mc/s$=9.8304$ Mc/s
$R_{c1}=60 \times 40.96$ ks/s$=2.4576$ Mc/s
$R_{ss}=1/T_{ss}=40.96$ ks/s

FIG. 8



W_1 W_2 W_1 W_2 W_1 W_2 W_1
W_3 W_4 W_3 W_4 W_3 W_4 W_3 W_4 W_3
W_2 W_1 W_2 W_1 W_2 W_1 W_2 W_1
W_3 W_4 W_3 W_4 W_3
W_2

FIG. 9

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	•••	59
0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		1
1	1	1	0	1	1	1	0	1	0	1	0	1	1	0	0	1	1	1	0	1	1	1	1	0	0	1	1	•••	0
2	1	0	1	1	1	0	1	0	1	0	0	1	0	0	1	1	1	0	1	1	1	1	0	0	1	1	1		1
3	1	1	1	1	0	1	0	1	0	0	1	0	0	1	1	1	0	1	1	1	1	0	0	1	1	1	1		0
4	1	1	1	0	1	0	1	0	0	1	0	0	1	1	1	0	1	1	1	1	0	0	1	1	1	1	1	•••	1
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7	1	1	0	1	0	0	1	0	0	1	1	1	0	1	1	1	1	0	0	1	1	1	1	1	0	0	0	•••	0
8	1	0	1	0	0	1	0	0	1	1	1	0	1	1	1	1	0	0	1	1	1	1	1	0	0	0	0		1
9	1	1	0	0	1	0	0	1	1	1	0	1	1	1	1	0	0	1	1	1	1	1	0	0	0	0	0		0
10	1	0	0	1	0	0	1	1	1	0	1	1	1	1	0	0	1	1	1	1	1	0	0	0	0	0	1	•••	1
11	1	0	1	0	0	1	1	1	0	1	1	1	1	0	0	1	1	1	1	1	0	0	0	0	0	1	1		0
12	1	1	0	0	1	1	1	0	1	1	1	1	0	0	1	1	1	1	1	0	0	0	0	0	1	1	0		0
13	1	0	0	1	1	1	0	1	1	1	1	0	0	1	1	1	1	1	0	0	0	0	0	1	1	0	0	•••	1
14	1	0	1	1	1	0	1	1	1	1	0	0	1	1	1	1	1	0	0	0	0	0	1	1	0	0	0		0
15	1	1	1	1	0	1	1	1	1	0	0	1	1	1	1	1	0	0	0	0	0	1	1	0	0	0	0		0
16	1	1	1	0	1	1	1	1	0	0	1	1	1	1	1	0	0	0	0	0	1	1	0	0	0	0	1	•••	1
17	1	1	0	1	1	1	1	0	0	1	1	1	1	1	0	0	0	0	0	1	1	0	0	0	0	1	0		1
18	1	0	1	1	1	1	0	0	1	1	1	1	1	0	0	0	0	0	1	1	0	0	0	0	1	0	0		1
19	1	1	1	1	1	0	0	1	1	1	1	1	0	0	0	0	0	1	1	0	0	0	0	1	0	0	0	•••	0
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21	1	1	1	0	0	1	1	1	1	1	0	0	0	0	0	1	1	0	0	0	0	1	0	0	0	1	1		1
22	1	1	0	0	1	1	1	1	1	0	0	0	0	0	1	1	0	0	0	0	1	0	0	0	1	1	0	•••	1
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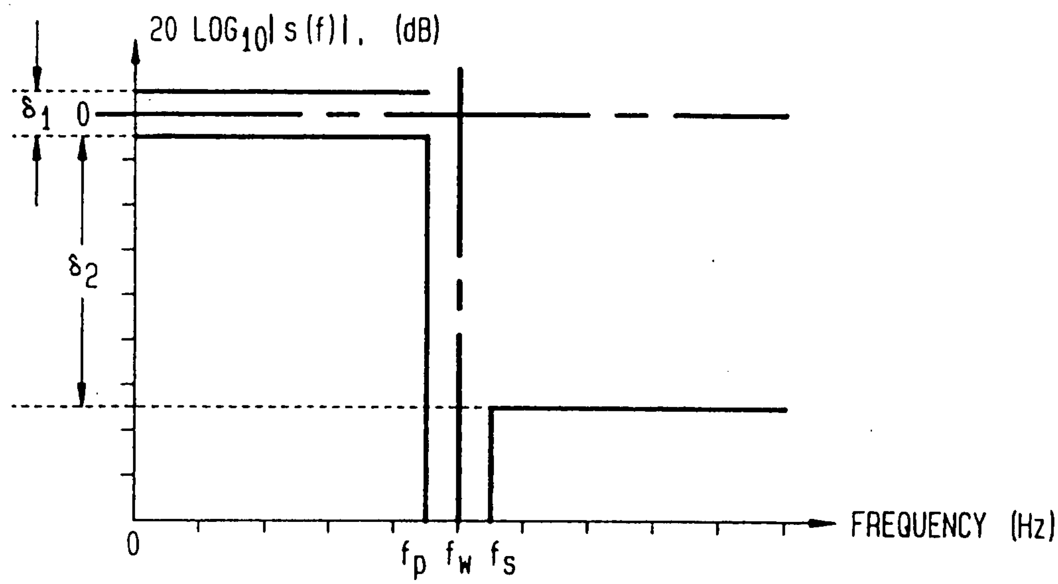
25	1	1	1	1	1	1	0	0	0	0	0	1	1	0	0	0	0	1	0	0	0	1	1	0	1	1	0	•••	0
26	1	1	1	1	1	0	0	0	0	0	1	1	0	0	0	0	1	0	0	0	1	1	0	1	1	0	1		1
27	1	1	1	1	0	0	0	0	0	1	1	0	0	0	0	1	0	0	0	1	1	0	1	1	0	1	0		1
28	1	1	1	0	0	0	0	0	1	1	0	0	0	0	1	0	0	0	1	1	0	1	1	0	1	0	1	•••	1
29	1	1	0	0	0	0	0	1	1	0	0	0	0	1	0	0	0	1	1	0	1	1	0	1	0	1	0		1
30	1	0	0	0	0	0	1	1	0	0	0	0	1	0	0	0	1	1	0	1	1	0	1	0	1	0	0		1
31	1	0	0	0	0	1	1	0	0	0	0	1	0	0	0	1	1	0	1	1	0	1	0	1	0	0	0	•••	0
⋮			⋮			⋮			⋮			⋮			⋮			⋮			⋮			⋮			⋮		
59	1	0	1	0	1	1	1	0	1	0	1	0	0	1	0	0	1	1	1	0	1	1	1	1	0	0	1	•••	0

FIG. 10



f_p=4.13952 MHz, f_W=4.9152 MHz, f_S=5.65248 MHz
δ_1=1 dB, δ_2=-60dB

FIG. 11

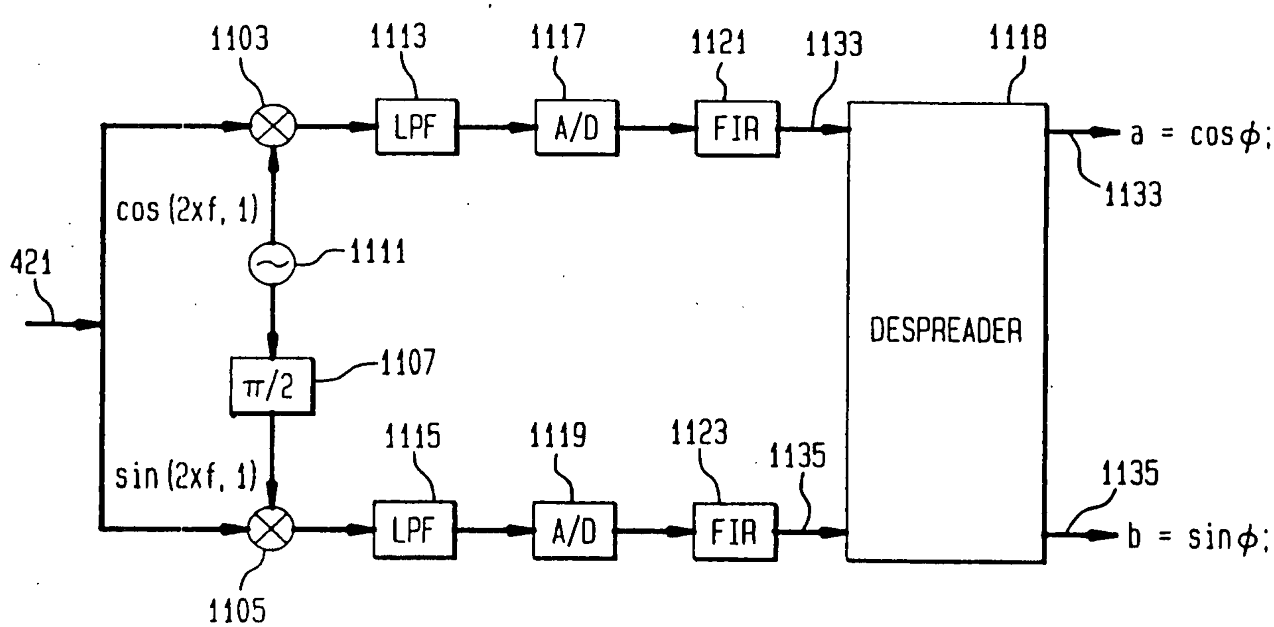


FIG. 12

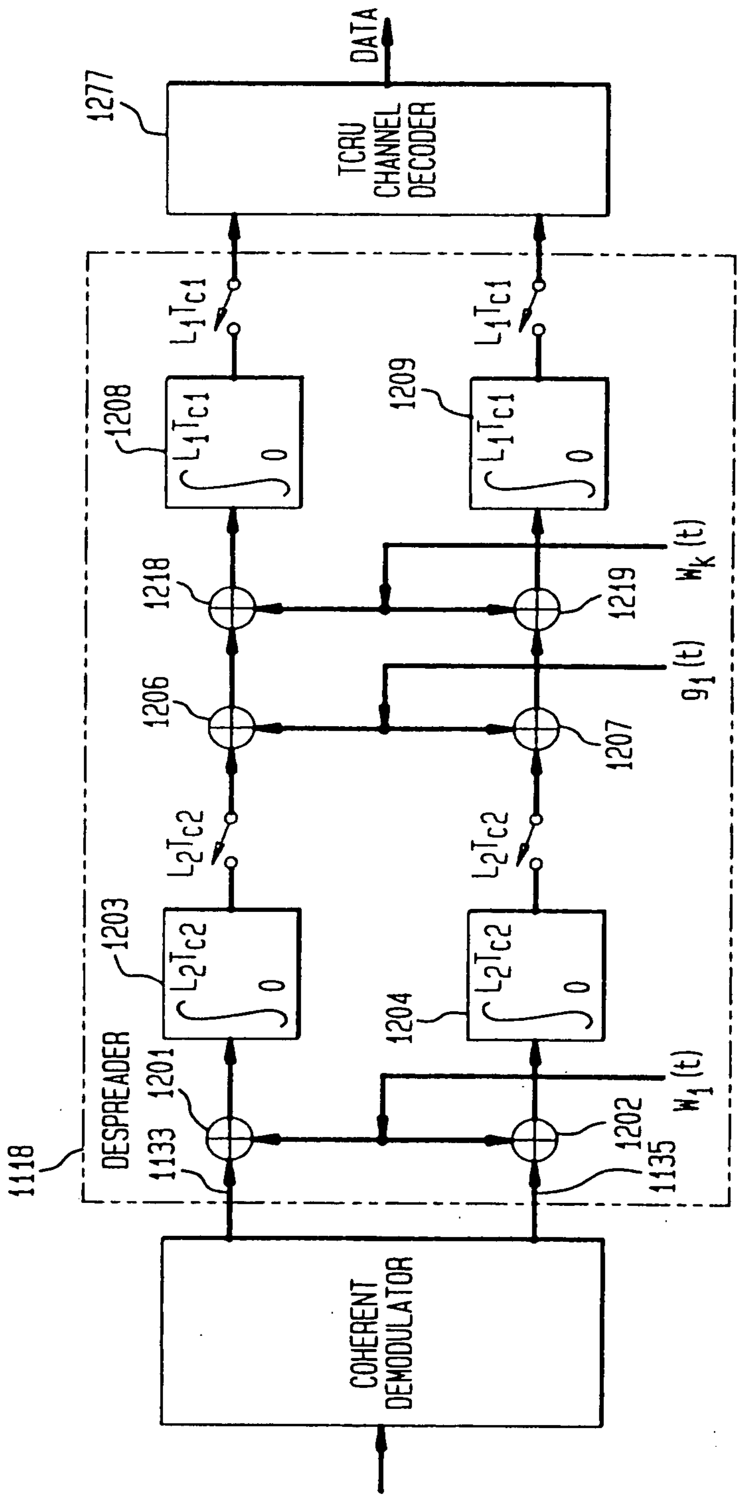

DATA
1277
TCRU
CHANNEL
DECODER
1118
DESPREADER
1133
1135
1201
1202
1203
1204
1206
1207
1208
1209
1218
1219
L2Tc2
L1Tc1
W1(t)
g1(t)
WK(t)
COHERENT
DEMODULATOR

FIG. 13

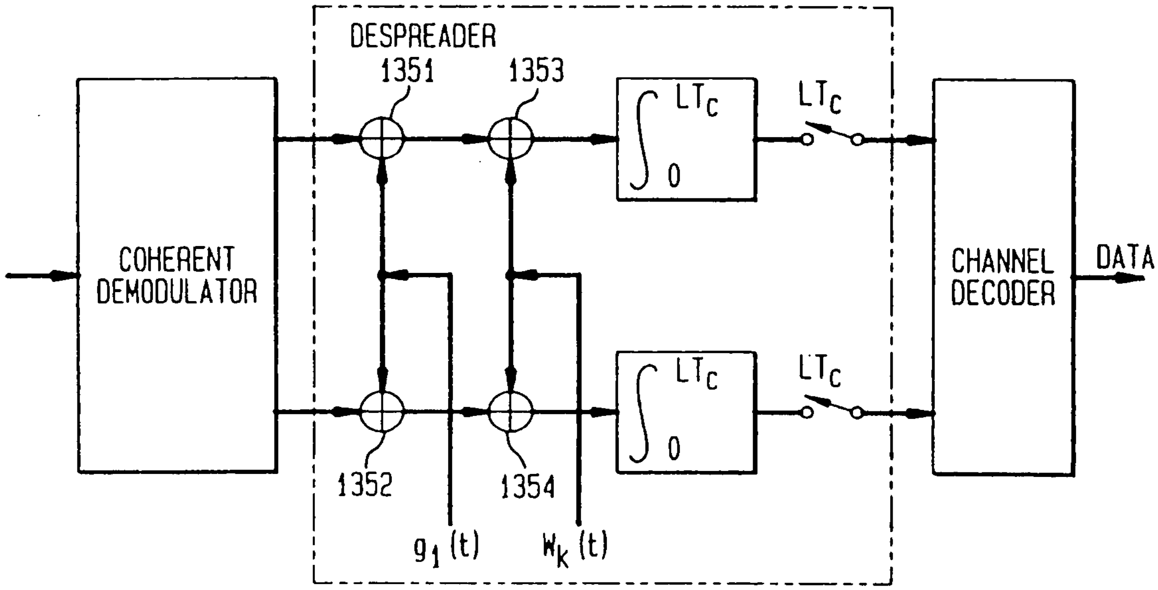

DESPREADER
1351
1353
LTc
LTc
0
COHERENT DEMODULATOR
CHANNEL DECODER
DATA
LTc
LTc
0
1352
1354
g1 (t)
Wk (t)

FIG. 14

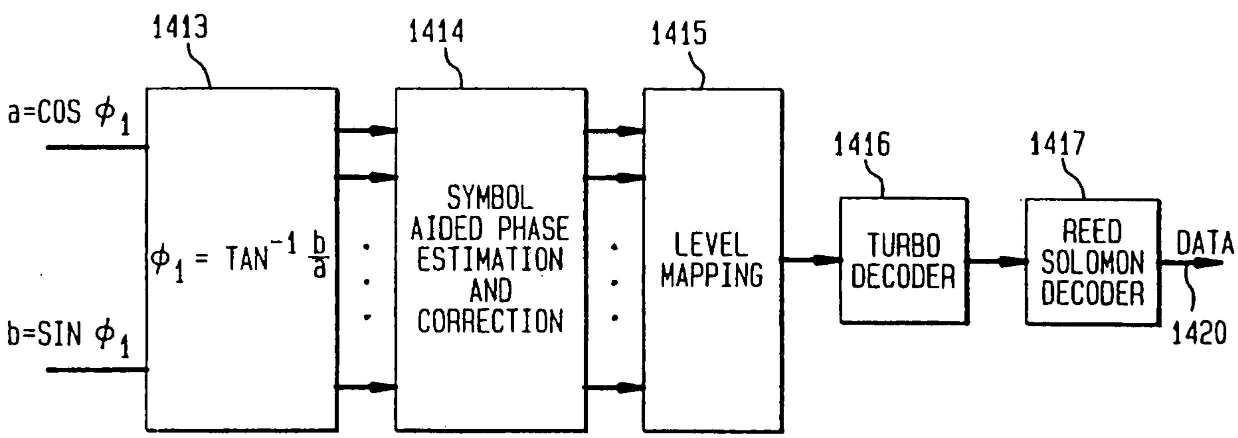

1413
1414
1415
a=COS φ1
b=SIN φ1
φ1 = TAN-1 b/a
SYMBOL AIDED PHASE ESTIMATION AND CORRECTION
LEVEL MAPPING
1416
TURBO DECODER
1417
REED SOLOMON DECODER
DATA
1420

FIG. 15

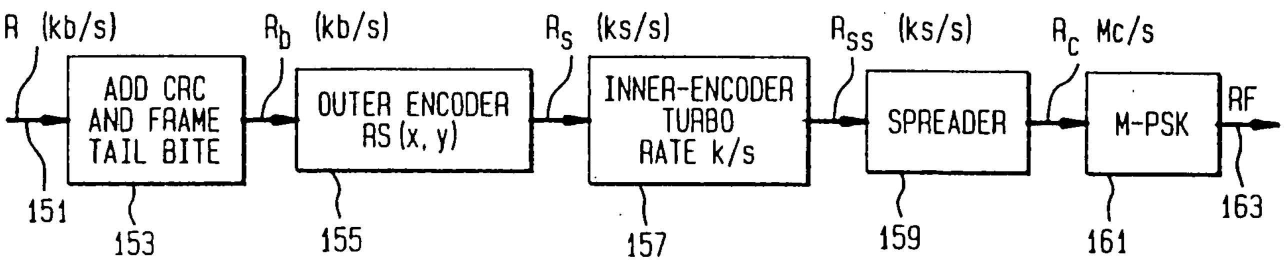

R (kb/s)
ADD CRC AND FRAME TAIL BITE
R_b (kb/s)
OUTER ENCODER RS (x, y)
R_s (ks/s)
INNER-ENCODER TURBO RATE k/s
R_{ss} (ks/s)
SPREADER
R_c Mc/s
M-PSK
RF
151
153
155
157
159
161
163

FIG. 16

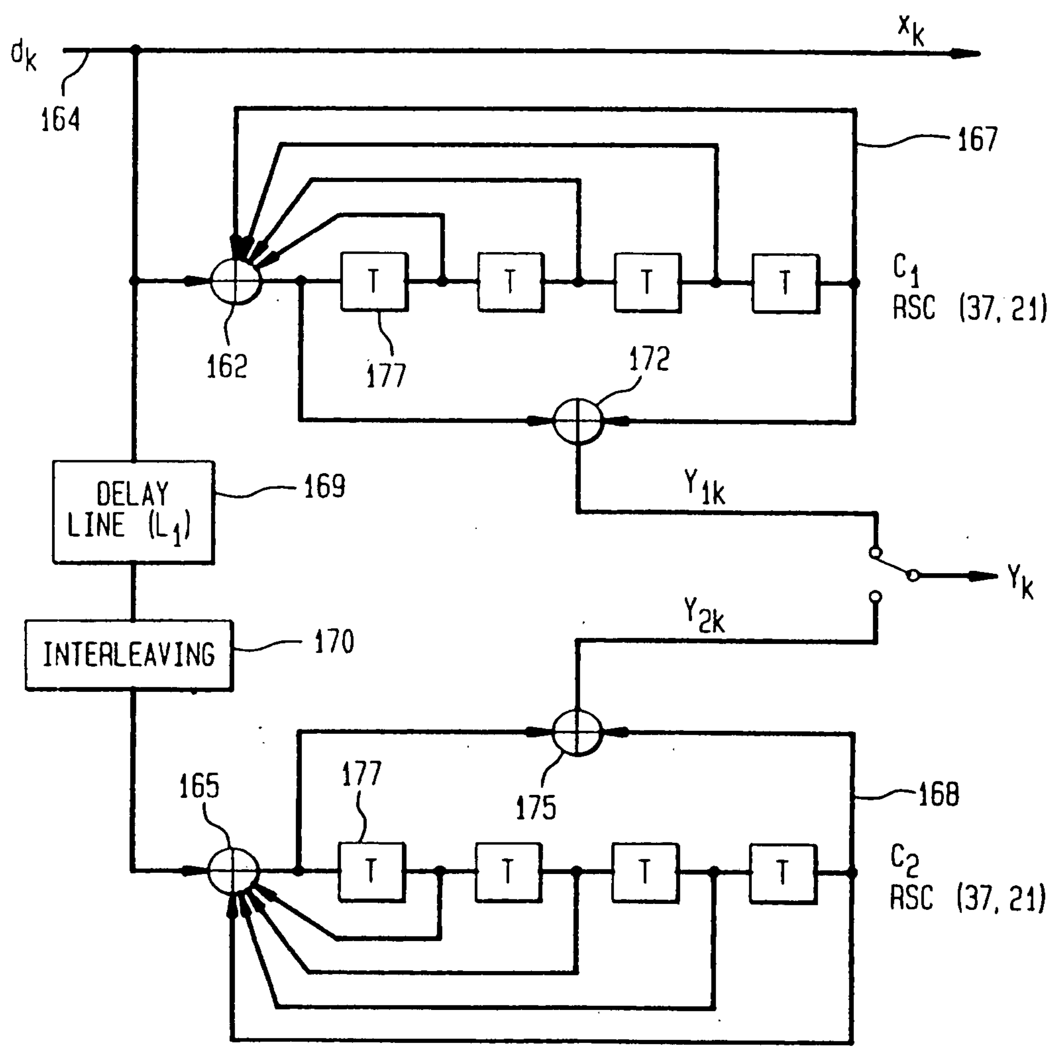
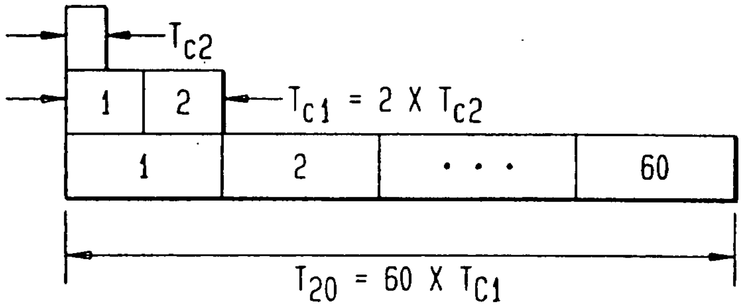
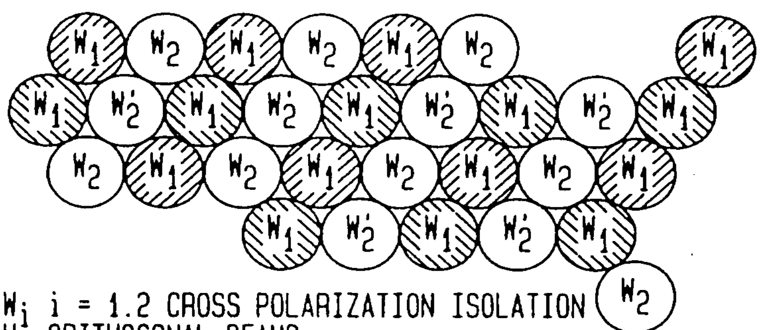

d_k
164
x_k
167
T
C_1
RSC (37, 21)
162
177
172
Y_{1k}
DELAY LINE (L_1)
169
Y_k
Y_{2k}
INTERLEAVING
170
165
177
175
168
C_2
RSC (37, 21)

FIG. 17



L_1=60, L_2=2
R_{c2}=4 X 4.9152 Mc/s=9.8304 Mc/s
R_{c1}=60 X 81.92 ks/s=4.9152 Mc/s
R_{ss}=1/T_{ss}=81.92 ks/s

FIG. 18



$W_i.W_i'$ i = 1.2 CROSS POLARIZATION ISOLATION
$W_1.W_2$ ORITHOGONAL BEAMS

FIG. 19

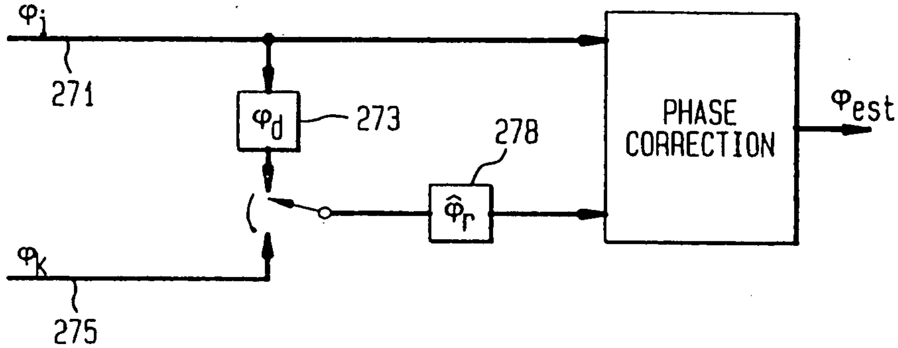
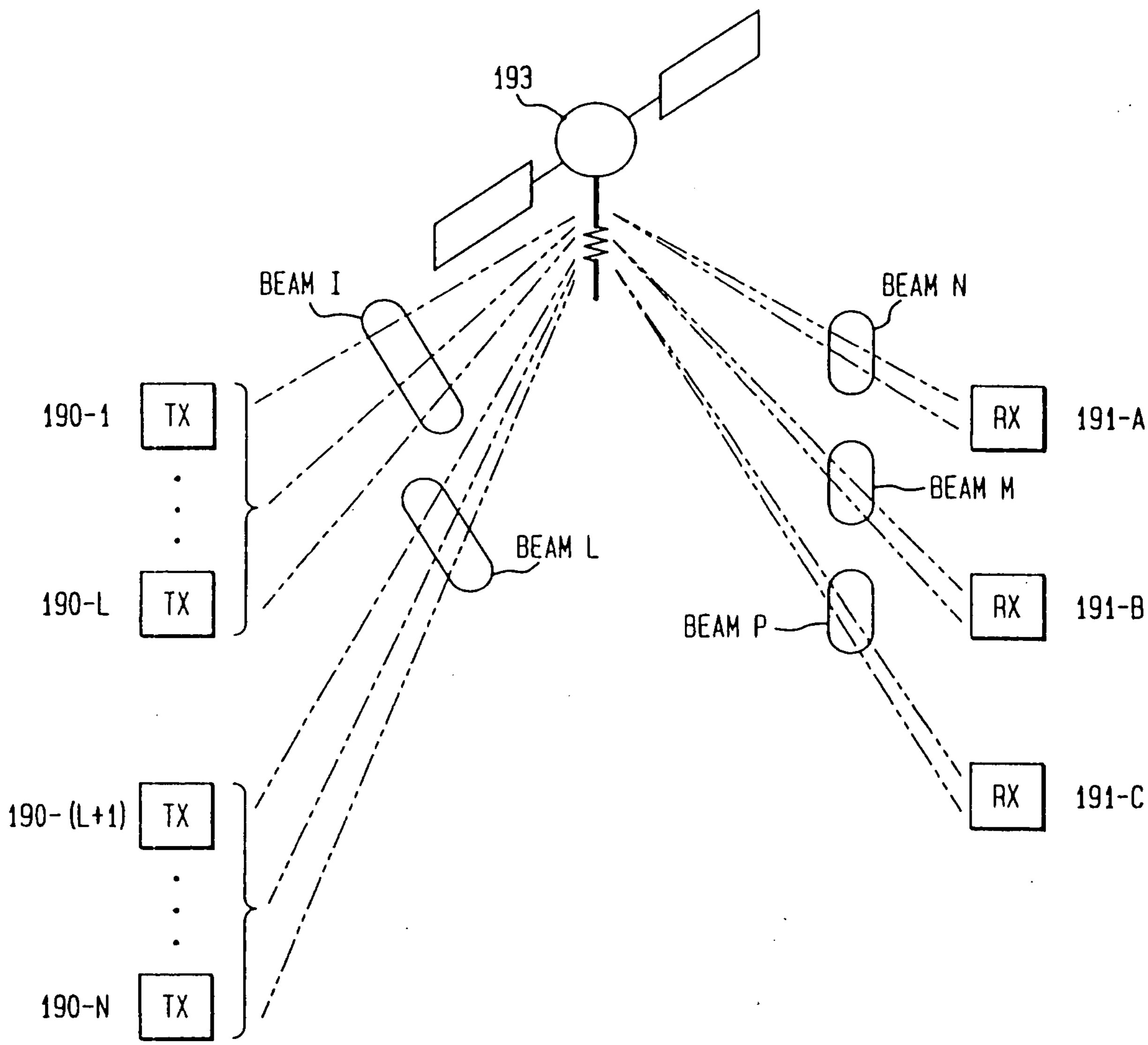


FIG. 20


193
BEAM I
BEAM N
190-1
TX
RX
191-A
BEAM M
BEAM L
190-L
TX
RX
191-B
BEAM P
190-(L+1)
TX
RX
191-C
190-N
TX